MAP READING

MILITARY MAP READING

BY

CAPTAIN C. O. SHERRILL

CORPS OF ENGINEERS, U. S. ARMY

INSTRUCTOR IN ENGINEERING

U. S. SERVICE SCHOOLS

FORT LEAVENWORTH, KANSAS

Fourth Edition

Twenty-fifth Thousand

Adopted by the War Department for use by the Organized Militia

Adopted for use at the Army Service Schools, Fort Leavenworth, Kansas

Adopted for use of the U. S. Marine Corps

The Collegiate Press

GEORGE BANTA PUBLISHING COMPANY

Menasha, Wisconsin

SALES AGENTS
U. S. CAVALRY ASSOCIATION
FORT LEAVENWORTH, KANSAS

PRESS OF
GEORGE BANTA PUBLISHING CO.
MENASHA, WIS.

TABLE OF CONTENTS

PARS.

MILITARY MAP READING

CHAPTER I.—Classes of maps; Map Reading; Scales of Maps; Methods of Representing Scales; Construction of Scales; Scale Problems; Scaling Distances from a Map; Problems in Scaling Distances 10-21

CHAPTER II.—Methods of Representing Elevations; Contours; Relation of Map Distances, Contour Intervals, Scales and Slopes; Problems; Hachures 22-32

CHAPTER III.—Directions on Maps; Methods of Orienting a Map; To Locate One's Position on a Map; The True Meridian; Conventional Signs 33-40

CHAPTER IV.—Visibility; Visibility of Areas; Visibility Problems; On Using a Map in the Field; Maps Used for War Games and Tactical Problems 41-54

MILITARY MAP READING.

CHAPTER I.

CLASSES OF MAPS.

10. *Maps* are representations to scale (usually on a plane) of portions of the earth's surface. They are of various kinds, depending on the use for which they are intended, and may or may not represent relative heights as well as horizontal distances and directions. For instance, the ordinary County Map shows only roads, boundaries, streams and dwellings. *A Topographical Map* shows the horizontal relation of points and objects on the ground represented and in addition gives the data from which the character of the surface becomes known with respect to relative heights and depressions.

11. Suppose an officer is sent out by his commander in unknown country to pick out a good position for camp and outpost, and to report upon his return the military features of the site selected. On visiting the ground selected his eye can only take in a very limited portion from any one position, and even with the most careful examination from various points he would get only a very general idea of the larger features. But if on returning he tries to

describe in words to his commander the position selected, he would find his task almost impossible. The simplest sketch, however, made by him on the ground, even if not correct as to scale or elevations, would enable him to give his commander as good an idea as he had himself obtained; but a report based on an accurate map or sketch would be full and complete. It is almost impossible to organize and carry out marches, reconnaissances, concentrations, etc., without maps upon which to base the orders.

12. Almost all classes of maps have some military uses. For example, an ordinary map showing the location of important towns, large rivers, and roads, is useful for arranging the concentration of large bodies of troops or for following the operations of a campaign, but it is far from being in sufficient detail for the purposes of those who plan or study the smaller operations of war. A complete military map, on the contrary, must give both the horizontal and vertical relations of the ground and also a representation of all military features of the area.

A Military Map, therefore, is one which gives the relative distances, elevations, and directions of all objects of military importance in the area represented.

MAP READING.

13. By Map Reading is meant the ability to grasp by careful study not only the general features of the map, but to form a clear conception or mental picture of the appearance of the ground represented. This involves the ability to convert map distan-

ces quickly to the corresponding ground distances; to get a correct idea of the network of streams, roads, heights, slopes, and all forms of military cover and obstacles. The first essential therefore, for map reading is a thorough knowledge of the scales of maps.

SCALES OF MAPS.

14. A map is drawn to scale—that is, each unit of distance on the map must bear a fixed proportion to the corresponding distance on the ground. If one inch on the map equals one mile (63360 inches) on the ground, then $\frac{1}{3}$ inch equals $\frac{1}{3}$ mile, or $63360 \div 3 = 21120$ inches on the ground, etc. The term "*Distance*" in this book is taken to mean horizontal distance; vertical distance to any point is called elevation or depression, depending on whether this point is higher or lower than the one from which the measurements are made. For example, the distance from Frenchman in a straight line to McGuire (Leavenworth Map) is 2075 yards, but to walk this distance direct would require the ascent and descent of Sentinel Hill, so that the actual length of travel would be considerably greater than the horizontal distance between the two points.

In speaking of distance between towns, cities, etc., horizontal distance is always meant. In referring to such distances, that by the shortest main road is usually intended. For example, from Fort Leavenworth to Kickapoo (Leavenworth Map) is 5 miles, measured over the 5-17-47 road. The fixed ratio (called the scale of the map) between distances on the map and the corresponding distances on the ground should be constantly kept in mind.

METHODS OF REPRESENTING SCALES.

15. There are three ways in which the scale of the map may be represented:

1st. *By an expression in words and figures;* as 3 inches=1 mile; 1 inch=200 feet.

2d. *By what is called the natural scale or the Representative Fraction* (abbreviated R. F.), which is the fraction whose numerator represents units of distance on the map and whose denominator represents units of horizontal distance on the ground, being written thus: R. F. $\frac{1 \text{ inch}}{1 \text{ mile}}$ $\frac{1}{63360}$, 1:63360, or 1 is to 63360,—all of which are equivalent expressions, and are to be understood thus: $\frac{\text{Map}}{\text{Ground}}$ that is the numerator is distance on the map, the denominator is horizontal distance on the ground. This fraction is usually written with a numerator of unity, no definite length of unit being specified in numerator or denominator. In this case, the expression means that one unit of distance on the map equals as many of the same horizontal units of distance on the ground as there are units in the denominator.

The R. F. is synonymous with the term scale of the map. Therefore, if the scale be changed the R. F. will be changed in exactly the same manner and amount. To increase the R. F., (being a fraction), its denominator is decreased. For the same reason the greater the distance on the ground represented by an inch on the map, the smaller is the scale of the map. The greater the dimensions of a map to represent a given area *the larger is the scale* (that is R. F.) and the smaller the *denominator* of the latter.

3rd. *By what is called a Graphical Scale.* A Graphical Scale is a line drawn on the map, divided into equal parts, each division being marked, not with its actual length, but with the distance which it represents on the ground, (see figure 1. and Leavenworth Map).

Every map should have a graphical scale because this gives true readings no matter how the size of the map is changed in reproduction or due to weather conditions; whereas the R. F. and the number of inches per mile placed on the original map are no longer true if the size is altered. The R. F. is important, however, because it is intelligible to persons unfamiliar with the units of distance used in making the map. An expression of the scale in words and figures is also valuable because rapid mental estimates can be made of the distance between points on the ground by estimating the number of inches between these points on the map.

16. Graphical Scales are of two kinds depending on the purpose for which they are constructed: (1) *Working Scales* and (2) *Reading Scales.*

A Working Scale is used in making a sketch or map and shows graphically the value of tens, hundreds, etc. of the units of distance used in making the map or sketch. For example, if distances were measured by counting strides or taking the time of a horse trotting, in making a sketch, then it would be necessary to construct a scale of strides or minutes of horse's trot on the desired scale of the sketch. This enables you to lay off on the sketch distances, measured thus, directly from the working scale without the necessity of calculating at each halt how many inches on the sketch are equal to the number of strides or minutes, passed over.

A Reading Scale shows the distance on the map corresponding to even tens, hundreds etc. of some convenient and well known unit of measure, such as the foot, yard, mile. For example, figure 2 shows a reading scale of yards, reading to hundreds on the *Main Scale,* and to 25 yards on the *Extension* (see fig. 1). A scale may be both a working and a reading scale when the unit of measure used in making the map is a well known length such as the foot, or yard. A reading scale in the units of one country often will not be satisfactory for use by persons of a different nationality, because of their unfamiliarity with the length of units of distance used. An officer coming into possession of such a map would be unable to get a correct idea of the distances between points represented. He would find it necessary to convert the scale into familiar units as yards or miles, see problem 4, par. 19.

It will readily be seen that a map's scale must be known in order to have a correct idea of distan-

Graphical Scale.

Fig. 1

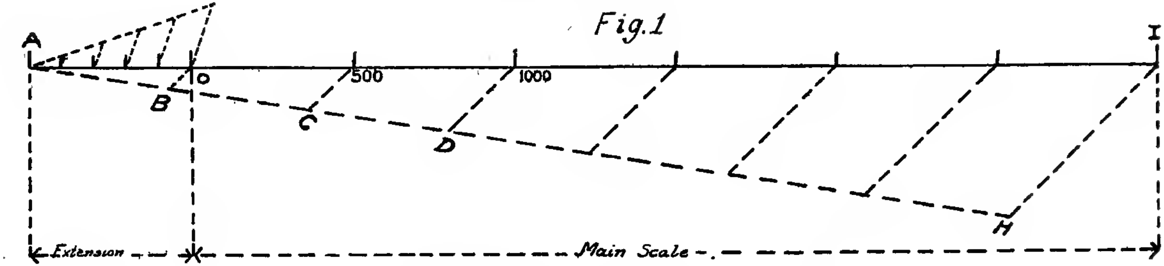


Fig. 2

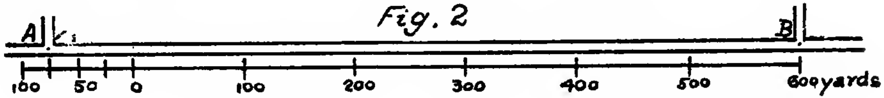


Fig 4

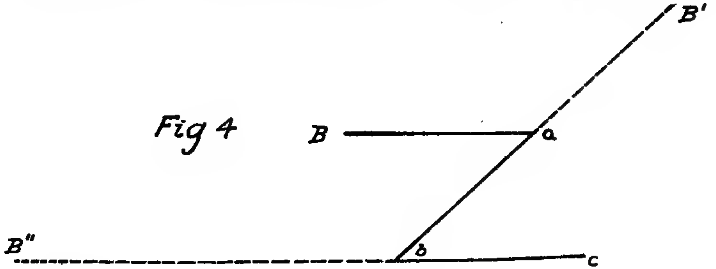


Fig. 3

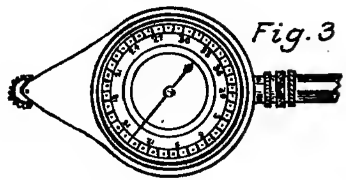


Plate 1.

ces between objects represented on the map. This is essential in determining lengths of march, ranges of small arms and artillery, relative length of marches by different roads, etc. Therefore, if under service conditions you should have a map without a scale or one expressed in unfamiliar units, you would first of all be compelled to construct a graphical scale to read yards, miles etc., or one showing how many miles one inch represents. Or, if you were required to make a sketch by pacing, it would be necessary to construct your scale of paces on the proper R. F.

CONSTRUCTION OF SCALES.*

In the construction of scales the following are the steps taken:

(1). Find from the given data the R. F. of the map; (2) the length in inches of the unit of measure used, as pace, chain, rate of horse's trot, yard, mile etc.; (3) the number of the units of measure corresponding to one inch on the map; and (4) the length in inches on the map corresponding to an even number of tens etc. of these units of distance.

*The following relations are constantly used and should be familiar to every one:

1 mile=63360 inches=5280 feet=1760 yards.

R. F. $\frac{1}{63360}$=Scale 1 inch to 1 mile.

R. F. $\frac{1}{21120}$=Scale 3 inches to 1 mile.

R. F. $\frac{1}{10560}$=Scale 6 inches to 1 mile.

In the scale problems, units of distance on the ground will be indicated by small CAPITALS, where any confusion may exist.

SCALE PROBLEMS.

HAVING GIVEN THE R. F.

19. Problem 1. Assume R. F. $\frac{1}{21120}$. (a) To find the value of one inch on the map in miles on the ground. Solution: If one inch on the map represents 21120 inches on the ground, then one inch (on the map), will represent as many MILES (on the ground) as one mile (=63360 inches) is contained in 21120 inches. $21120 \div 63360 = \frac{1}{3}$, or one inch$=\frac{1}{3}$ MILE is the scale of the map, usually expressed thus: 3 inches=1 MILE.

(b) To construct a graphical scale of yards. Solution: If one inch=21120 INCHES, then one inch$=21120 \div 36 = 586.66$ YARDS. Now suppose a scale about 6 inches long is desired. 6 inches$=6 \times 586.66 = 3519.96$ YARDS, so that in order to get as nearly a six inch scale as possible to represent even hundreds of YARDS, assume 3500 YARDS to be the total number to be represented by the scale. The question is then, how many inches are necessary to show 3500 YARDS. Since 1 inch=586.66 YARDS, as many inches are necessary to show 3500 as 586.66 is contained in 3500 YARDS, or $3500 \div 586.66 = 5.96$ inches. Now lay off with scale of equal parts A I, figure 1,=5.96 inches (5 inches+48 50ths) and divide it into 7 equal parts by construction shown in figure 1, as follows: Draw a line A H making any convenient angle with A I and lay off on it 7 equal convenient lengths, so as to bring H approximately opposite

I. Join H and I, and with ruler and triangle draw the intermediate lines through B, C, D, etc., parallel to H I. These lines divide A I into 7 parts each=500 yards. The left division, called the extension, is similarly divided into 5 parts each equal to 100 yards.

Problem 2. R. F. $\frac{1}{10000}$. length of stride 60 inches. Construct a working scale of strides.

Solution: 1 STRIDE=60 INCHES. 1 inch= 10000 INCHES=$\frac{10000}{60}$ STRIDES.

Suppose a 3 inch scale is desired. 3 inches=$3\times\frac{10000}{60}$=500 STRIDES. Construct the scale by dividing up three inches into 5 parts of 100 STRIDES each by the method of figure 1.

Problem 3. A sketcher's horse trots one mile in 8 minutes. Construct a scale of minutes and quarters, R. F. $\frac{1}{21120}$. Solution:

8 MINUTES=63360 INCHES.

1 INCH=$\frac{(8)}{(63360)}$ MINUTES.

From which 21120 INCHES=$\left(21120 \times \frac{8}{63360}\right)$ MINUTES=$\frac{8}{3}$=$2\frac{2}{3}$ MINUTES.

Since 1 inch=21120 INCHES,

1 inch=$2\frac{2}{3}$ MINUTES.

6 inches=$(6\times2\frac{2}{3})$ MINUTES=16 MINUTES.

Construct the scale by dividing the 6 inch line into 16 equal parts for MINUTES, and the left one of these spaces into 4 equal parts to read quarters of a minute.

R. F. NOT GIVEN.

Problem 4. An American officer in Germany secures a map showing a scale of 1 centimeter=1 KILOMETER.

Required (a) the R. F. of this map, (100 centimeters=1 meter; 1000 meters=1 kilometer.)

Solution: $\frac{1 \text{ cm}}{1 \text{ KM}} = \frac{.01 \text{ m}}{1000 \text{ M}} = \frac{1}{100000} = \text{R. F.}$

(b) How many inches to the MILE in this scale?

(c) Construct a reading scale of MILES for this map.

Problem 5. (Where a map has a graphical scale on which the divisions are not in even parts of inches and are marked in ground distances of some unfamiliar unit as kilometers, meters, chains, etc. It is required to construct a graphical scale in familiar units). By measurement on the scale of a German map, 1.08 inches reads 1 KM. (a) What is the R. F. of the map? (b) Construct a graphical scale to read YARDS. Solution 1.08 inches=1 K= 1000 METERS (1 m=39.37 in.). 1.08 inches= 39370 INCHES or 1 inch=36453 INCHES, or

R. F.$= \frac{1}{36453}$; whence construct graphical scale as in Problem 1 (b).

Problem 6. (Where a map has no scale at all. In this case measure the distance between two definite points on the ground represented, by pacing or otherwise, and scale off the corresponding map distance. From this find the R. F. and construct the graphical scale as above). For example, suppose the distance between two road crossings, identified on map and ground, is found to be 500 PACES (31 inches each), and on the map to be $\frac{3}{4}$ inch. In this case $\frac{3}{4}$ inch$=(500\times31)$ INCHES.

$$1 \text{ inch} = \frac{500 \times 31}{\frac{3}{4}} = 20666.66 \text{ INCHES; R. F.} = \frac{1}{20666.66}$$

From this R. F. a scale of yards is constructed as in Problem 1 (b).

CHANGING THE SCALE OR THE AREA OF MAPS.

Note the difference between increasing or decreasing *the scale* (*linear dimensions*) of a map, and its *size* (*area*). To double the size of a map whose sides are six inches and 4 inches ($6\times4=24$ square inches), the reproduction would be 48 sq. inches that is $6\sqrt{2}$ by $4\sqrt{2}$ on the sides. To reduce a 9 inch by 6 inch map to $\frac{1}{3}$ its size (area), the sides would be $\frac{9}{\sqrt{3}}$ and $\frac{6}{\sqrt{3}}$. $\frac{9}{\sqrt{3}}\times\frac{6}{\sqrt{3}}=\frac{54}{3}=18=\frac{1}{3}$ of 54. The general rule is that to change the area of a map any multiple, as 2 times, 3 times, $\frac{1}{3}$ times, $\frac{1}{4}$ times, its original area, each of the linear dimensions is multiplied by the square root of the multiple as $\sqrt{2}$, $\sqrt{3}$, $\frac{1}{\sqrt{3}}$ $\frac{1}{\sqrt{4}}$, etc.

Problem 7. A map, R. F. $\frac{1}{6000}$, is enlarged so that the distance on the map between two towns A and B is 3 times as great as on the original. What is the new R. F.? Answer. R. F. $\frac{1}{2000}$, (R. F. multiplied by 3).

Problem 8. A map has R. F. $\frac{1}{8000}$. (a) What is the scale of this map in inches per MILE if its linear dimensions are decreased one-fifth in reproduction? (b) The original area of the map was 8 by 16 inches. What is the new R. F., if its area is four times as large as that of the original?

Solution to (b): $\frac{1}{8000} \times \sqrt{4} = \frac{1}{8000} \times 2 = \frac{1}{4000} =$ R. F.

CORRECTION OF ERRONEOUS SCALES.

It sometimes happens that in making a map an error exists in the length of the unit of measure that is not discovered until later. The question is then (1) how to find the true scale of the map as made, and (2) how to correct the working scale so it will be true for the future work.

Problem 9. An officer is ordered to make a position sketch, scale 6 inches=1 MILE. He uses a working scale of 62 inch strides. Afterwards he finds that his stride is actually 58 inches.

Required: (a) What is the R. F. of the sketch actually made; and (b) is the scale larger or smaller than ordered?

Solution: (a) R. F. assumed $\frac{1}{10560}$. Since his stride was shorter than assumed, in plotting any given distance on the sketch (as 1 inch), he had actually passed over a shorter distance on the ground than he thought. Consequently his true R. F. would have a smaller *denominator* in the proportion of the true and assumed rates, 58 to 62.

$$10560 \times \frac{58}{62} = 9878.70 \text{ INCHES.}$$

The true R. F. of sketch was $\frac{1}{9878.70}$

(b) The R. F. $\frac{1}{9878.70}$ is larger than R. F. $\frac{1}{10560}$ having a smaller denominator, and therefore the scale of the sketch as made is too large.

Problem 10. A mounted sketch is made on the scale of 3 inches=1 MILE, with a horse rated at 5.5 MINUTES=1 MILE. The true rate of the horse is 1 MILE in 6 MINUTES.

Required: The true R. F. of the sketch.

Solution: Since the horse took longer to pass over a mile, than was thought, he traveled slower than he was rated. There was accordingly too short a distance covered at the end of any given number of minutes. Hence the distance on the ground corresponding to any plotted map space, say one inch, was less than supposed, or the denominator of the R. F. is really less than 21120, in the proportion of the two rates: $21120 \times \frac{5.5}{6} = 19360$. The true R. F. is $\frac{1}{19360}$.

Problem 11. A sketcher is ordered to make a sketch on the scale R. F. $\frac{1}{21120}$. He supposes he takes a 29 inch pace and uses this for his working scale. Afterwards he finds that a distance of 4000 yards scaled from his sketch measures on the ground 4125 yards.

Required (a) His true length of pace.

(b) The true R. F. of the sketch as made.

$\frac{4000 \times 36}{29} = 4965$ = number of paces taken in traveling the distance, *whether he assumed the correct length of pace or not.* But in-as-much as the corresponding distance on the ground measured 4125 yards, therefore dividing this distance by the number of paces taken in passing over it, gives the true length of each pace: $\frac{4125 \times 36}{4965} = 29.9$ inches = actual length of pace.

(b) If the distance of 4000 yards scaled from the sketch actually measured 4125 yards on the ground, the sketch is smaller than intended and the R. F. $\frac{1}{21120}$ is too large and must be decreased in the proportion of these two distances, i. e. its denominator must be increased. (See par. 15). Therefore, $\frac{1}{21120} \times \frac{4000}{4125} = \frac{1}{21780}$ =true R. F.

THE LARGEST SCALE POSSIBLE ON A GIVEN SHEET.

Problem 12. A sheet of drawing paper 28 inches by 21 inches is to contain a map of an area of ground ten miles by seven miles and leave a border of at least $1\frac{1}{2}$ inches.

Required: The largest scale that can be used.

Solution: Taking out the border of $1\frac{1}{2}$ inches on every side leaves 25×18 inches available. The largest possible scale will be determined by finding the R. F. of a map that would require 25 inches to show 10 miles, and one that would require 18 inches to show 7 miles and using *the smaller of the two.* 25 inches=10MI.=63360×10=633600 INCHES.

$$1 \text{ inch} = \frac{633600}{25} = 25344 \text{ INCHES. R. F.}$$

$\frac{1}{25344}$ is the scale of a map that will exactly fit the length.

18 inches=7 MI.=63360×7=443520 INCHES.

1 inch=24640 INCHES. R. F. $\frac{1}{24640}$ is the largest scale that can be used on the width.

The map that just will go on the 25 inch length will cover less than the 18 inch width and therefore

R. F. $\frac{1}{25344}$ is the greatest scale that can be used. The map on any larger scale, as for instance $\frac{1}{24640}$, would not go on the length of 25 inches.

GENERAL SCALE PROBLEMS.

Problem 13. Construct a working scale of paces for a map on the scale of 12 inches=1 MILE, one hundred and twenty paces being equal 100 yards.

14. A reduction of the General Staff map of France is published on a scale of R. F. $\frac{1}{200000}$

(a) Construct a graphical scale to show 15 miles on this map. 4.752 inches = 15 Mi.

(b) Construct a graphical scale to show 15 kilometers (1 meter=39.37 inches, 1 kilometer=1000 meters). 2.95 inches = 7.5 c. m. = 15 K. M.

15. The R. F. of a map size 10 x 12 inches is $\frac{1}{62500}$.

(a) What is the scale of this map when reduced to one-fourth its present size? $\frac{1}{125000}$

(b) Suppose that the length of the map becomes 9.5 inches in a photographic reproduction. Is the map enlarged or reduced? What is its R. F.?

16. What is the R. F. of the Leavenworth Map herewith? How many inches on it equal one mile?

17. A map was drawn on the scale R. F. $\frac{1}{10000}$ but in reproduction its dimensions were changed so

that 800 yards on the ground scales 875 yards on the map.

Required: (a) Construct a reading scale to give correct distances from this map. (b) What is the correct R. F.? 1 ÷ 9143.

18. Draw a suitable scale of yards for a map 10 by 12 inches to show an area of 5 by 6 miles.

19. The R. F. of a map is 1÷10000.

Required: (a) the distance in miles shown by one inch on the map. (b) Construct a graphical scale of yards; also one to read miles (problem 1 b).

20. The map from which figure 16 was reduced has a graphical scale on which 1.56 inch=one kilometer. Required (a) the R. F. of the original map. (b) Number miles represented by one inch. (c) Graphical scale to read hundreds of yards; one to read miles.

21. A map has marked on it R. F. 1÷62500. Required: (a) graphical scale to read miles, halves and quarters. (b) What is the value in yards of one inch on the map? 1 inch = 1736.1 Yds.

22. You are in hostile country and secure a map of the locality without a scale. 20 inches on the map is the distance apart of the 20th and 21st degrees of latitude. Required: (a) a graphical scale of yards. (b) The R. F. of the map. (1° latitude=68.8 miles).

23. What is the R. F. of map, figure 20 A?

SCALING DISTANCES FROM A MAP.

20. Having considered the scale relation and the construction of scales, it is well to mention the use of scales in taking distances from a map.

1st. Apply a piece of straight edged paper to the distance between two points to be measured and mark the distance on the paper. Now apply the paper to the graphical scale as shown in figure 2, and read the number of yards on the main scale adding the number on the extension, with a total of 600+75=675 yards.

2d. Take the distance A B, figure 2, off with a pair of dividers and applying the dividers, thus set, on the graphical scale read off 675 yards.

3d. Use an instrument called a map measurer,* figure 3. Setting the hand on its face to read zero, roll the small wheel from A to B. Now roll the wheel back to zero in an opposite direction along the graphical scale, noting the number of yards passed over on the scale. Or, having rolled from A to B, note the number of inches on the dial and multiply this by the number of miles per inch given on the map. *A map measurer is especially valuable for use in map problems and war games.*

4th. Apply scale of inches to the line and multiply the number of inches between the points by the number of miles per inch given on the map.

5th. Copy off the graphical scale on the edge of a piece of paper, and then apply this directly to the map.

If the line to be measured changes direction, the same methods are used.

By the 1st Method. Each portion in succession is taken off on the straight-edge paper.

*For sale by Keuffel & Esser Co., New York. Price $2.00.

By the 2d Method: The dividers are first applied to B *a* (figure 4), then the leg at B is placed at B′ in the extension of *b a;* now the leg at *a* is placed at *b,* making $b\ B' = b\ a + a\ B$. Now rotate the leg from B′ to B″ in prolongation of *b c.* Move leg at *b* to *c.* The total distance is now included in the spread of the legs and the dividers are applied to the scale. By the *3d Method*: The map measurer is rolled from B to *a, a* to *b, b* to *c* (figure 4), causing the small wheel always to rotate in the same direction. *By the 4th Method*: The scale of inches is placed on B *a,* then rotated about *a* and placed along *b a,* thus adding B *a* to *a b,* etc., to the end, then obtain the number of miles as explained above.

PROBLEMS IN SCALING DISTANCES.

21. Problem 1. What is the distance from 70 (U. S. Pen.) to A via Prison Lane and Pope Avenue (Ft. Leavenworth Map)? Check by 3d method.

Problem 2. What is the distance from 70 to G over the Atchison Pike? Use the 4th method and check with the divider method.

Problem 3. A patrol at XVII (On Grant Avenue) is ordered to move by the shortest road to 17. Which road will it take?

Problem 4. Company A is at Grant and Metropolitan Avenues, Company B is at the Polo Grounds. They are ordered to arrive at Frenchman's at the same time. Assuming both move at 3 miles an hour, which will start first and how much? Give route of each.

Fig. 5 A

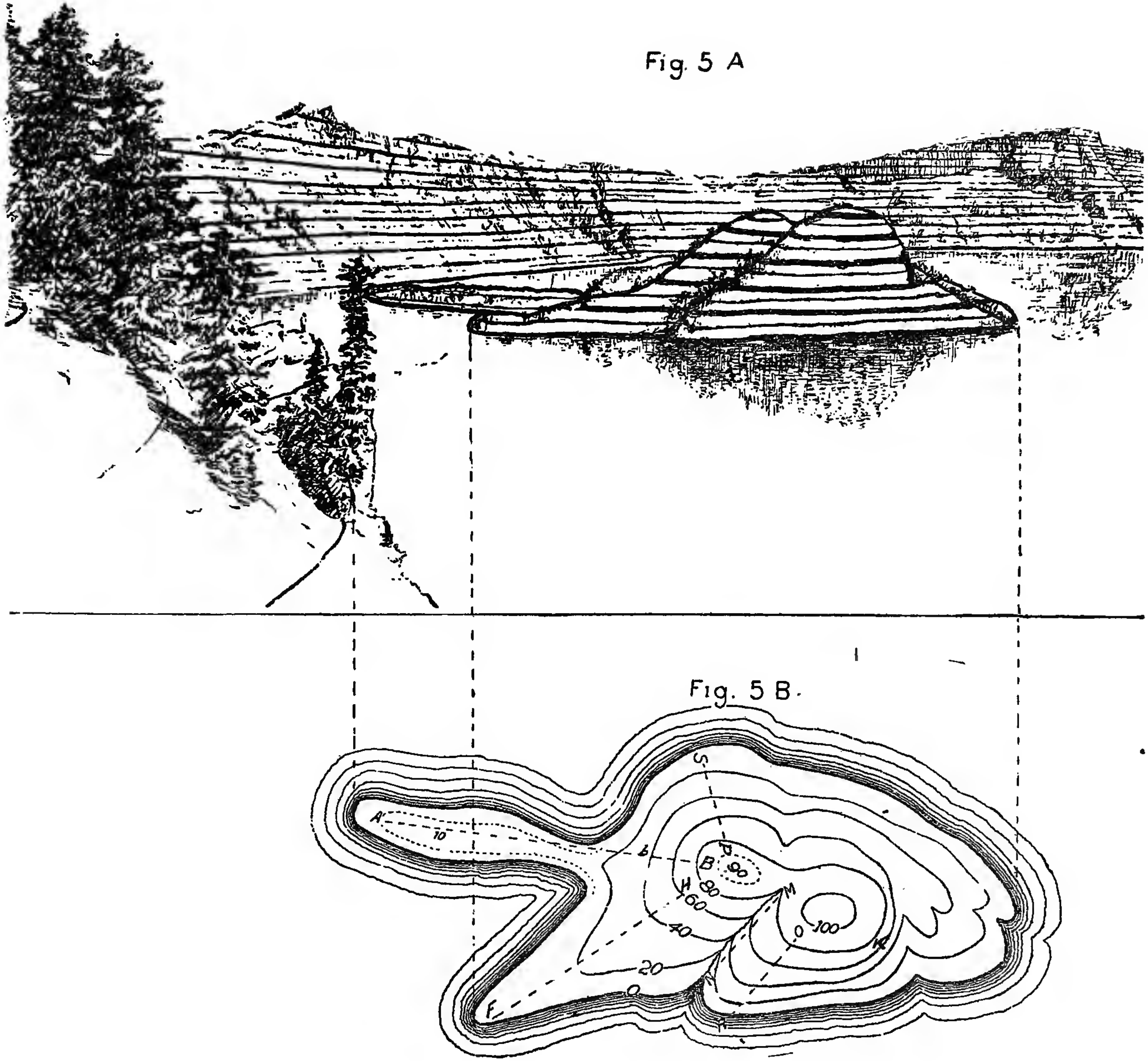


Fig. 5 B.

CHAPTER II.

METHODS OF REPRESENTING DIFFERENCES OF ELEVATION.

22. Since maps are representations, on a plane surface, of ground which has not only extent horizontally but vertically, it is necessary to have some means of rapidly determining elevations. This is accomplished in one of two ways.

1st. *By means of contours,* which are the lines cut from the surface of the earth by imaginary horizontal planes at equal vertical intervals from each other, figure 5 A.* The representations of these lines to scale on a map are called contours, figure 5 B, and this is the meaning usually intended by the term "contour." These relations of contours will be evident from figures 5 A and 5 B. Suppose that formerly this island was entirely submerged and that by a sudden disturbance the lake subsided until the highest peak of the island extended slightly above the water. Later a succession of falls of the water level of 20 feet each occurred, until now the island stands more than 100 feet out of the lake, and at each of the 20 foot elevations a distinct water line is left. These water lines are perfect contours referred to the lake as a reference (or *datum*) plane. It will be observed that on the gentle slope along

*Based on photograph of Crater Lake made by Geological Survey.

F-H the 20 foot contour is far from the lake, and from the 40 foot contour. But on the steep slope at R the contours are very close together horizontally and almost directly over the water. Hence, it is seen that contours far apart horizontally indicate gentle slopes, and contours close together horizontally, steep slopes. It is also seen that the shape of the contours gives an accurate idea of the form of the island. Figure 5 B shows the *horizontal projection* of the contours in 5 A, that is, each point dropped vertically down on a plane. The contours in 5 B give an exact representation not only of the general form of the island, the two peaks, the stream M-N, the saddle M, the water shed from F to H, and the cliff at K, but the slopes of the ground at all points. From this we see that the nearer the contours on a map are to each other the steeper the slope represented. The contours of a cone (figure 6) are concentric circles, equally spaced because the slope of a cone is constant at all points. The contours of a concave cone are close together at the center (top), growing farther apart toward the outer circle (bottom), figure 8, showing that the slope is steeper at the top than at the bottom. The contours of a hemisphere are far apart at the center (top), growing closer together near the circumference (bottom), figure 7.

23. The following additional points should be remembered about contours:

(a) A *water shed or spur,* along which the water divides, flowing away from it on both sides, is

Plate 3

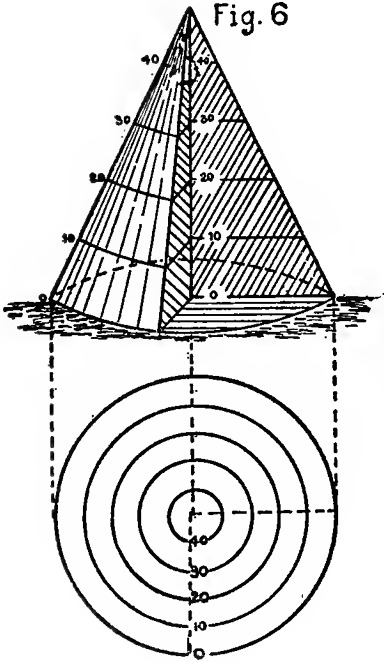


Fig. 6

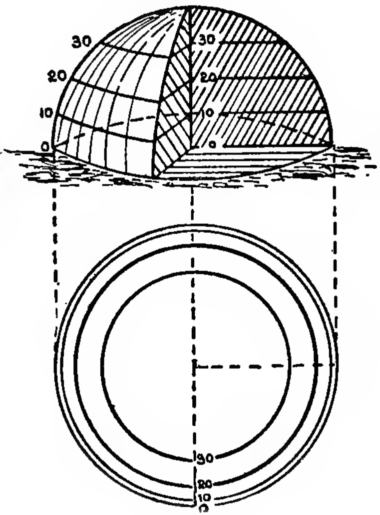


Fig. 7

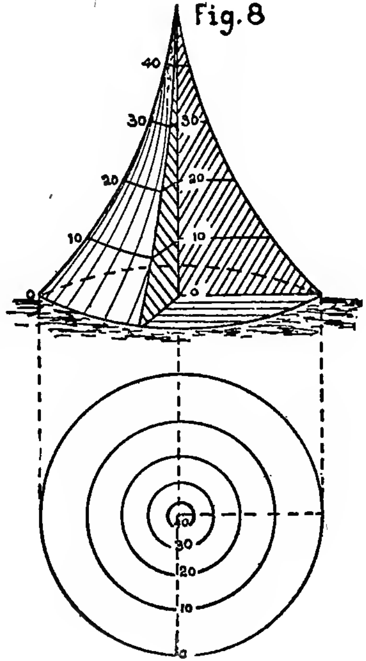


Fig. 8

indicated by the higher contours bulging out toward the lower ones. (F-H figures 5 A and 5 B).

(b) A *water course, or valley,* along which rain falling on both sides of it joins in one stream, is indicated by the lower contours bending out sharply toward the higher ones. (M-N figures 5 A and 5 B).

(c) Contours of different elevations which unite and become a single contour, represent *a vertical cliff*. The contours of the vertical faces of the quadrant cut out of the cone, figure 6, would be shown by two single lines, perpendicular to each other at the center of the concentric circles.

(d) Two contours of different elevations which cross each other represent an *overhanging cliff*.

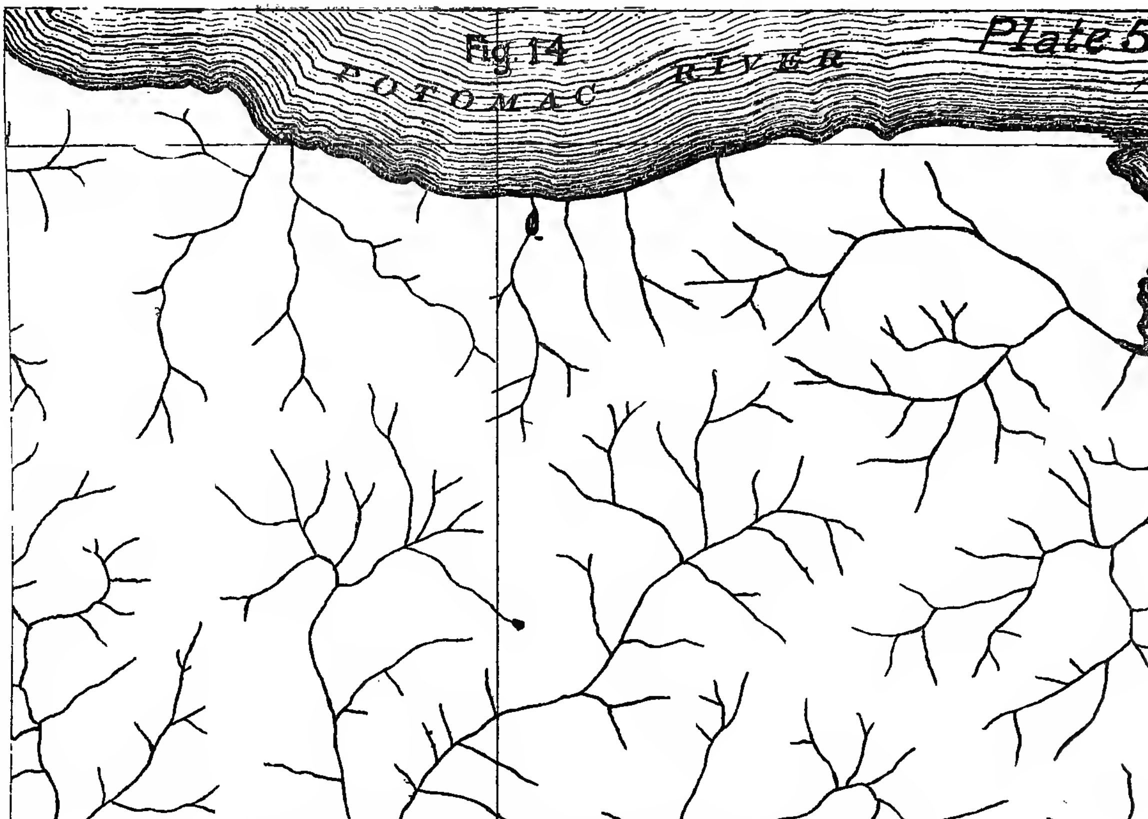
(e) A closed contour represents either a *hill top* (crest), as P-B figure 5 B, or a *depression.* A hill top is shown when the smallest closed contour is higher than the adjacent contour, and a depression when the smallest closed contour is lower than the contour next to it.

(f) *A saddle* (*or col*) is shown by two contours of greater elevation on two sides of it, and two of lower elevation on the other two sides, as at M figure 5 B. M is a saddle between the two peaks 90 and 100.

24. Fig. 14 shows the stream system of the area represented in figure 15. Note the steep cliffs at A, figure 15, also observe that the roads generally fol-

Plate 5

Fig. 14



B. DRAINAGE: PART OF MONTROSS (VA.-MD.) SHEET

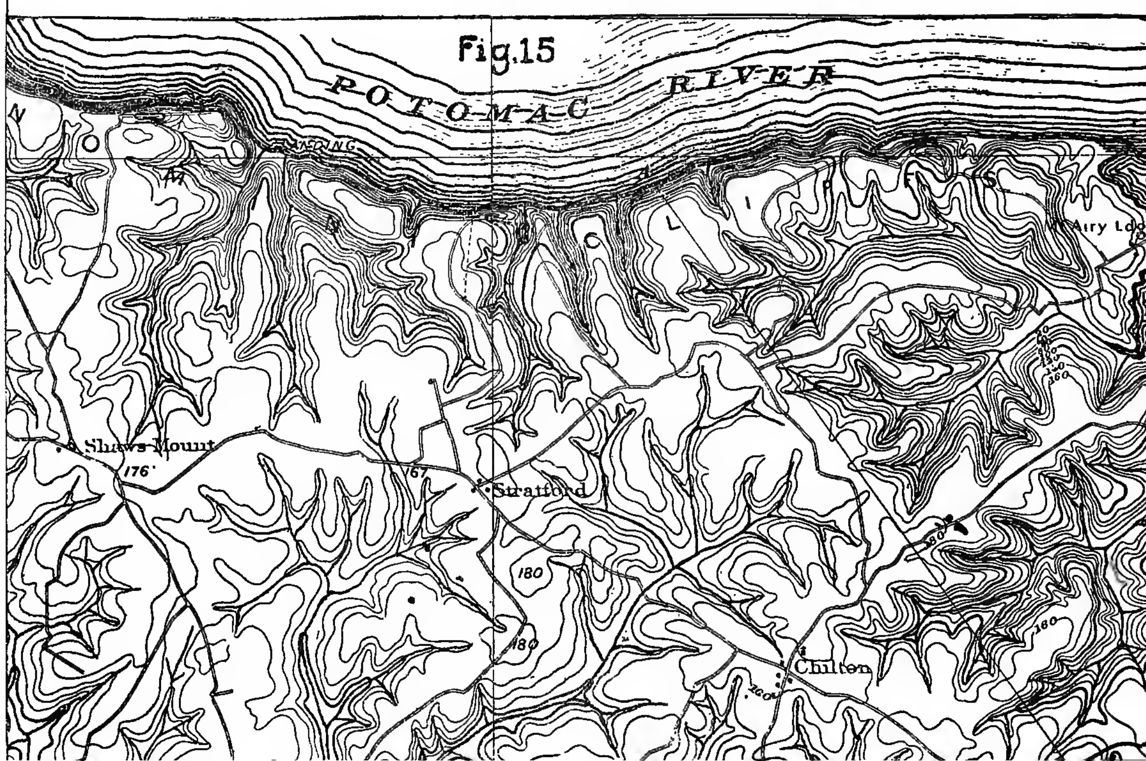
Scale 1:62500

½ 0 1 2 miles

Contour interval 20 feet.

Datum is mean sea level.

Fig. 15



low the flat country. The road from Mt. Airy Lodge to Chilton makes a detour to avoid the steep slopes between these two places, but the road from Chilton to Stratford lies straight across the valley because its slopes are gentle, as shown by the greater distance apart of contours. A study of the network of streams in figure 14, in comparison with the contours in figure 15, will show the value of carefully noting the position and direction of flow of streams in map reading.

RELATION OF MAP DISTANCES, CONTOUR INTERVALS, SCALES AND SLOPES.

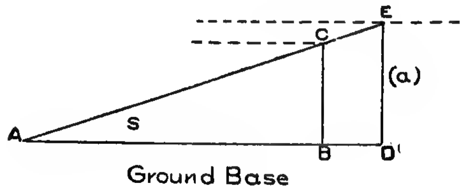
25. The horizontal distance on the ground between two contours is called the *Horizontal Equivalent* (H. E.) The horizontal distance between two contours on the map is always referred to by using the abbreviation *M. D.* (*map distance*). Since the M. D. depends on the slope of the ground represented, it can be calculated for various degrees of slope of the ground and a scale of M. D.'s constructed with which slopes can be at once read off from the distance apart of any particular contours. This is based on the fact that 57.3 feet (688 inches) horizontally on a 1 degree slope gives a rise of 1 foot. These relations are not absolutely correct, but up to 20° are so nearly exact that the error is not appreciable on the scales used on military maps.

Slope degrees	Rise feet	Inches Horizontal
1°	1	688
2°	1	$\frac{688}{2}=344$
3°	1	$\frac{688}{3}=229$
4°	1	$\frac{688}{4}=172$
5°	1	$\frac{688}{5}=138$

26. To construct a scale of M. D.'s for a map on which it is not shown, take the distance in inches corresponding to one degree of slope, multiply this by the contour interval (V. I. in feet) and by the R. F. The result is the M. D. in inches for a 1° slope. Divide this value by 2, 3, 4 etc., then lay off these distances on a line to show 1°, 2°, 3°, etc., figure 10, p. 38. This relation between M. D., slope, V. I., and scale, is shown mathematically by the following formula: *M. D. (inches)=R. F.×V. I. (ft.)* ×688 *(inches)*÷ *(degrees)*. A discussion of the relations between the four terms of this formula gives rise to the principles governing slopes, map distances, scales, and vertical intervals of maps. These principles may be deduced by assuming that two of the quantities are fixed in value, and showing how the other two vary under those circumstances.

27. The equation may be written thus: M. D. $\times$ S $=$ R. F. $\times$ V. I. $\times$ 688. If now M. D. and S on two maps are assumed to be definite fixed values (as for example .65 inch M. D. and a corresponding slope of 1° on each map), their product is a constant. Hence the product of R. F. times V. I. must be constant to maintain the equality of both members of the equation and the R. F. must vary inversely with the V. I. for this condition to exist. That is. *If the R. F. (scale) is INCREASED the V. I. must be proportionally DECREASED and vice versa.* This principle is of great value in map reading and sketching because on all maps made on such a system a given M. D. represents the same slope.

The above principle may also be shown graphically as follows: Let figure (a) be assumed to be a vertical section of the ground in which the line A B is the horizontal distance and BC the V.I. between two contours A and C on the *ground*. If a certain M. D. on a map (No. 1) represents the distance AB on the ground, and the same M. D. on another map (No. 2) represents a *greater* ground distance, as AD, then the R. F. (scale) of map No. 2 is *smaller* than that of map No. 1 (see p. 4, last paragraph). But Map No. 2 has the larger V. I., as shown by the line ED in the figure: and hence the smaller the R. F. the larger the V. I. will be, if a given M. D. represents the same slope on all the maps.



28. Based upon the above principle, *the Normal System of Scales* prescribed for U. S. Army field sketches is as follows: For road sketches, 3 inches = 1 *mile,* vertical interval between contours 20 feet. For position sketches 6 inches = 1 *mile,* V. I. = 10 feet. Fortification sketches, 12 inches = 1 *mile,* V. I. = 5 feet. On maps made according to this system, *any given length of M. D. always corresponds to the same slope.* Figure 10 gives this normal scale of M. D.'s for slopes up to 8°. A scale of M. D.'s is usually printed on the margin of maps, near the graphical scale. Having given the scale of the map to find what its V. I. would be on the normal system: *Divide the number of inches to 1 mile into 60,* and the quotient will be the required V. I in feet. The normal system is valuable both in sketching and map reading, because the map distances which represent slopes up to 8° or 10° are soon learned and no time is lost in determining the slopes represented on the map, or the M. D.'s corresponding to observed slopes on the ground.

REPRESENTATION OF SLOPES.

29. Slopes are usually given in one of three ways: 1st in *degrees,* 2d in *percentages;* 3d, in *gradients.*

1st. A one degree slope means that the angle between the horizontal and the given line is 1 degree (1°).

2d. A slope is said to be 1, 2, 3, etc., percent, when 100 units horizontally correspond to a rise of 1, 2, 3, etc., of the same units vertically.

3d. A slope is said to be one on one ($1 \div 1$), two on three ($2 \div 3$), etc., when one horizontal unit corresponds to one vertical, three horizontal correspond to two vertical. The numerator usually refers to the vertical units. Degrees of slope are usually used in military matters; percentages are often used for roads, almost always for railroads; gradients are used for steep slopes, and usually for dimensions of trenches. Since 1° gives a rise of 1 foot at 60 feet (approximately), then 1° slope is equal to a gradient of 1 on 60 ($\frac{1}{60}$). 2° to 2 on $60 = \frac{1}{30}$. 3° to 3 on $60 = \frac{1}{20}$ etc. These values are useful for quickly giving an idea of the various degrees of slopes corresponding to gradients, and for converting one form of expression into another.

Arm.	*Gait.*	*Distance.*		*Reduction for Slopes. In yards horizontally per ten feet vertically**	*Maxi'm Slope Practicable.*	
		Yards per Minute.	*Miles per hour*		*Deg.*	*Vert ÷ Hor.*
Infantry	March	88	3	Up: 10 Down: 10 for slope above 10°	45	1÷1
	Double	147	5	Down: 10 Up: 20 for slope above 10°	10 20	$\frac{1}{6}$ $\frac{1}{3}$
	Advancing by rushes	16				
	Advancing and firing	40				
Cavalry	Walk	117	4	Up: 40 for slope above 5° Down: 60 for slope above 5°	25 20	½ $\frac{1}{3}$
	Trot	234	8	Up: Same as walk Down: Same as walk	15 10	¼ $\frac{1}{6}$
	Gallop	352	12	Up: Same as walk Down: Same as walk For slope above 3°	10 5	$\frac{1}{6}$ $\frac{1}{12}$
	Charge	440	15	Up: Same as walk For slope above 3° Down: Same as walk For slope above 2°	5 5	$\frac{1}{12}$ $\frac{1}{12}$
Artillery	Walk	117	4	Up: 10 Down: 60 For slope above 5°	10 10	$\frac{1}{6}$ $\frac{1}{6}$
	Trot	234	8	Up: 20 Down: 60 For slope above 3°	5 5	$\frac{1}{12}$ $\frac{1}{12}$
	Gallop	352	12	Up: 30 Down: 60 For slope above 2°	5 5	$\frac{1}{12}$ $\frac{1}{12}$

*Example. Artillery travels 60 min. on hilly road, going *up* hill a total of 100 ft. (vertically) and *down* hill a total of 50 ft. Required actual distance traveled: $117 \times 60 = 7020$ yds., distance if road bad been level. $\frac{10}{100} \times 10 + \frac{10}{50} \times 60 = 400$ yds. $7020 - 400 = 6620$ yds. actually traveled.

PROBLEMS.

31. 1. Construct a scale of M. D.'s for slopes from 1 to 3 degrees for a map whose V. I. is 20 feet, R. F. 1÷21120. Assume formula par. 26.

Solution: M. D.=(1÷21120)×20 ft×688 inches÷1°=.65 inch. Divide .65 inch by 1, 2, 3, giving M. D.'s for 1°, 2°, 3°. Lay these off as in figure 10.

2. Suppose you have a given slope between two contours, where the M. D. is 1 inch. How is the R. F. changed if, with the same V. I. and slope, the M. D. is 2 inches. Solution: V. I. and slope are constant, hence the M. D. varies directly with the R. F. The M. D. is doubled, hence the scale is doubled.

3. If on a given map a slope of 5° gives an M. D. of ½ inch, with a 10 foot V. I. what V. I. would give an M. D. of 1 inch to show the same slope. Solution: R. F. and S are constant, hence the V. I. varies directly as the M. D. which is doubled, hence the V. I. is 20 feet.

4. An M. D. of 2 inches, on a certain map represents a slope of 5°. How much must the scale of the map be altered for an M. D. of 5 inches to show 3° with the same V. I. as before? 2nd R. F. = 3/2 1st R. F.

These problems may be solved, by those familiar with the solution of equations, directly from the formula by substituting the quantities given directly in formula par. 26.

5. What is the steepest slope of the ground between "r" of the word Engineer and the bridge

VIII east of Engineer Hill*? Ans.—6°, between the 830 and 850 contours. Solution: Take off on edge of a piece of paper the distances between the contours on line "r"—VIII. Applying these to the scale of M. D's, on the map it is found that 6° is the greatest angle of slope.

6. What is the percentage of grade along Grant Avenue from 800 contour (north of XVII) north to the 850 contour*? Ans. $5\frac{1}{2}\%$. Solution: Take off the distance between the 800 and 850 contours on a piece of paper, and, applying this to the graphical scale on the map, it is found to be 300 yards (900 feet). There are five contour intervals between the two points, or a rise of 50 feet. In 900 feet horizontally there is a rise of 50 feet; in 100 feet, a rise of $50 \div 9$ feet$=5.5+$feet, or the grade is $5\frac{1}{2}\%$. (See definition of slope in percentage, par. 29.)

7. How would you express the above slope as a gradient?

8. Construct a scale of M. D.'s for the map in figure 15.

9. What is the steepest slope in degrees on the line A-B south of the Chilton-Mt. Airy Lodge road (figure 15)? What is the slope from B to the top of the first hill toward A (figure 15)?

10. Is the slope from the top of Sentinel Hill down to the main road at Gauss a convex, a concave, or a uniform slope? (see figures 6, 7 and 8)

11. Lay off a road from XXVI to the top of Long Ridge with a uniform 2° slope. Solution:

*Leavenworth Map.

Take the 2° M. D. on edge of piece of paper from scale of M. D.'s. Place one end of the 2° distance at XXVI (830) and note where the other end touches the 840 contour. From this point proceed as before to 850 contour, etc. Join up the points marked on the successive contours by a line, which is the road with grade of 2°. Could more than one road with a 2° slope be laid off from XXVI to the hill top?

12. Given the following information, draw 20 foot contours to show the features named, on the scale horizontally of 3 inches = 1 mile: A hill is a mile long and rises 200 feet high from a plane; one side is a concave slope; another, convex; at one point there is a vertical cliff 50 feet high.

13. With the same scale and V. I., show a hill with two peaks connected by a saddle from which a stream runs down the hill.

14. Model on a sand-pile the hill shown on Plate 2 and mark on the model the contours as shown in the plate.

HACHURES.

32. A second method of representing, on a map, elevations on the ground, is by means of vertical lines called Hachures, figure 17. This method is not used in the United States, and most of the countries of Europe have abandoned it. Germany, however, still uses hachures for its small scale maps. Figure 17 shows a full size copy of the 1÷100000 map of Metz and vicinity accompanying Griepenkerl's Letters on Applied Tactics, and it should be understood by every military student. By compar-

ing the Metz 1÷100000 map, figure 17, with the same area reduced from the 1÷25000 map, figure 16, on which contours are used, it will be seen that

Fig. 16

the contours give not only the exact elevations, but a much clearer idea of the slope of the ground than the hachures. Where no hachures are found on a hachured map, the ground is either a hill top or flat low land, and the slopes are roughly indicated by the varying blackness and nearness of the hachures. The darker the section the steeper is the slope. It often happens that a flat area is only known to be a

Fig. 17

hill top or valley by reference to surrounding features. Usually, however, figures indicate the heights of important points.

For reading maps of small scale a reading glass is of great assistance.

CHAPTER III.

DIRECTIONS ON MAPS.

33. Having given the means used for determining horizontal distances and relative elevations represented on a map, the next step is the determination of horizontal directions. When these three facts are known of any point, its position is fully determined. The direction line from which other directions are measured is usually the true north and south line (known as the *true meridian*); or it is the line of the magnetic needle, called the *Magnetic Meridian*. These two lines do not usually coincide, because at all points of the earth's surface the true meridian is the straight line joining the observer's station and the north pole of the earth whereas the direction of the magnetic meridian varies at different points of the earth, at some places pointing east, and at others west, of the true pole. At the present time the angle which the magnetic needle makes with the true meridian (called *Magnetic Declination*) at Fort Leavenworth is 8° 23′ east of north. It is important to know this relation, because maps usually show the true meridian, and an observer is generally supplied with a magnetic compass. Figure 11 shows the usual type of Box Compass furnished to officers. It has marked on its face the four cardinal points, N, E, S and W., and a circle which should be graduated in degrees to read from zero clockwise around to 360, i. e. an observation to the east being read 90°.

METHODS OF ORIENTING A MAP.

34. In order that directions on the map and on the ground shall coincide, it is necessary for the map to be oriented, that is, the true meridian of the map must lie in the same direction as the true meridian through the observer's position on the ground. Every road, stream or other feature on the map will then be parallel to its true position on the ground, and all the objects shown on the map can be identified and picked out on the ground.

1st Method. When the map has a magnetic meridian marked on it, as on the Leavenworth map. Place the sighting line of the compass, *a b,* figure 12 (i. e. the north and south line of the compass face), on the magnetic meridian of the map and rotate the map horizontally, until the north end of the needle points towards the north of its circle, whereupon the map is oriented.

35. Where only the true meridian is on the map: Construct a magnetic meridian, figure 12, if the declination is known, as follows: Place the true meridian of the map directly under the magnetic needle of the compass, while it is pointing to zero, then, keeping the map fixed, rotate the north of the compass circle *in the direction of the declination of the needle* until the needle has passed over an angle equal to the declination. Draw a line on the map in the extension of the N-S line of the compass circle (*a′ b′*), and this will be a magnetic meridian.

Plate 4

Fig. 11

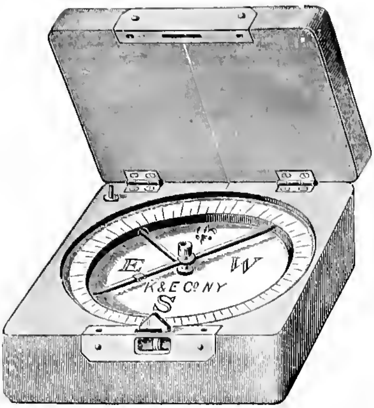


Fig. 12

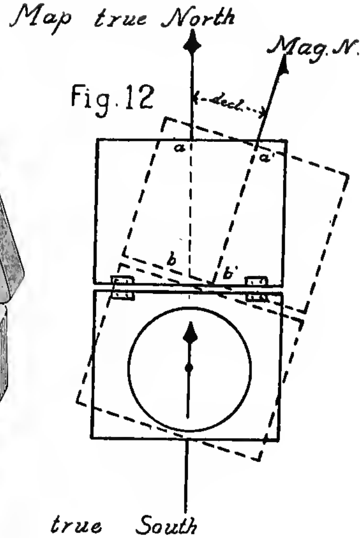


Fig 13

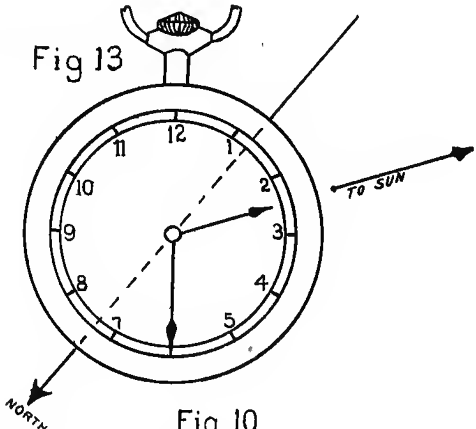
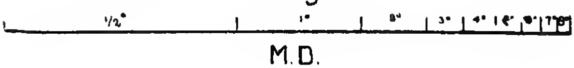


Fig. 10



Having constructed the magnetic meridian on the map, orient it as under the 1st method.

If the magnetic declination at the locality is not more than 4 or 5 degrees, the orientation will be given closely enough for map reading purposes by taking the true and magnetic meridians to be identical.

2nd Method. When neither the magnetic nor the true meridian is on the map: (a) If you can locate on the map your position on the ground, and can identify another place on the map which you can see on the ground, join these two points on the map by a line and hold the map so that this line points toward the distant point seen on the ground, whereupon the map is oriented. (b) If you can place yourself *on the line* of any two points visible on the ground and plotted on the map, rotate the map until the line joining the two points on the map points toward the two points on the ground, whereupon the map is oriented.

TO LOCATE ONE'S POSITION ON A MAP.

36. (1) *When the map is oriented by compass* (a). Sight along a ruler at an object on the ground while keeping the ruler on the plotted position of this object on the map, and draw a line toward your body. Do the same with respect to a second point visible on the ground and plotted on the map. The intersection of these two points is your map position.

(2) *When the map is oriented by the 2nd method* (b). Sight at some object not in the line used for orientation, keeping the ruler on the plotted position of this object and draw a line until it cuts the direction line used for orienting the map. This is your position on the map. Any straight line on the map such as fence, road, etc., is useful for orienting and thus finding your position. Usually your position may be found by characteristic landmarks, as cross roads, a crossing of railroad and highway, a juncture of streams, etc.

37. Having learned to orient a map and to find your position on it, you should secure a map of your vicinity and practice moving along roads at the same time keeping the map constantly oriented and noting exact features on the map as they are passed on the ground. This practice is of the greatest value in learning to read a map accurately; to estimate distances, directions and slopes correctly. The scale must be constantly kept in mind during this work, to assist in identifying your position at all times. Check off on the map the prominent points passed, such as bridges, cross roads, hill tops, villages, etc., and be sure that you identify correctly all objects of the terrain in your vicinity. You will find it difficult at first to constantly judge your position correctly, and from time to time will "lose yourself." When this occurs try to pick up your position again by careful observation of landmarks, assisted by an estimate of the map distance you should have traveled, at your present rate, from some point passed at a known hour.

TRUE MERIDIAN.

38. The approximate position of the true meridian may be found as follows: Point the hour hand of a watch toward the sun; the line drawn from the pivot to the point midway between the outer end of the hour hand and XII on the dial will point toward the south, figure 13. To point the hour hand exactly at the sun, stick a pin, or hold up a finger, as shown, figure 13, and bring the hour hand into the shadow. At night a line drawn toward the north star from the observer's position is approximately a true meridian. The "pointers" of the big dipper are very nearly in line with the north star.

CONVENTIONAL SIGNS.

39. Having learned the means used to represent horizontal distances, elevations, and directions on a map, it is next in order to study the method of representing the military features of cover, obstacles, communications and supply. They include various kinds of growths, water areas, and the works of man. These features are represented by Conventional Signs, in which an effort is usually made to imitate the general appearance of the objects as seen from a high point directly overhead. On account of this similarity of the object to its representation, the student will usually have no trouble in deciding at once the meaning of a new symbol. There is a constant tendency toward simplicity in the character of conventional signs, and very often simply the outline of an object, such as forests, cultivated ground, etc., is indicated with the name of

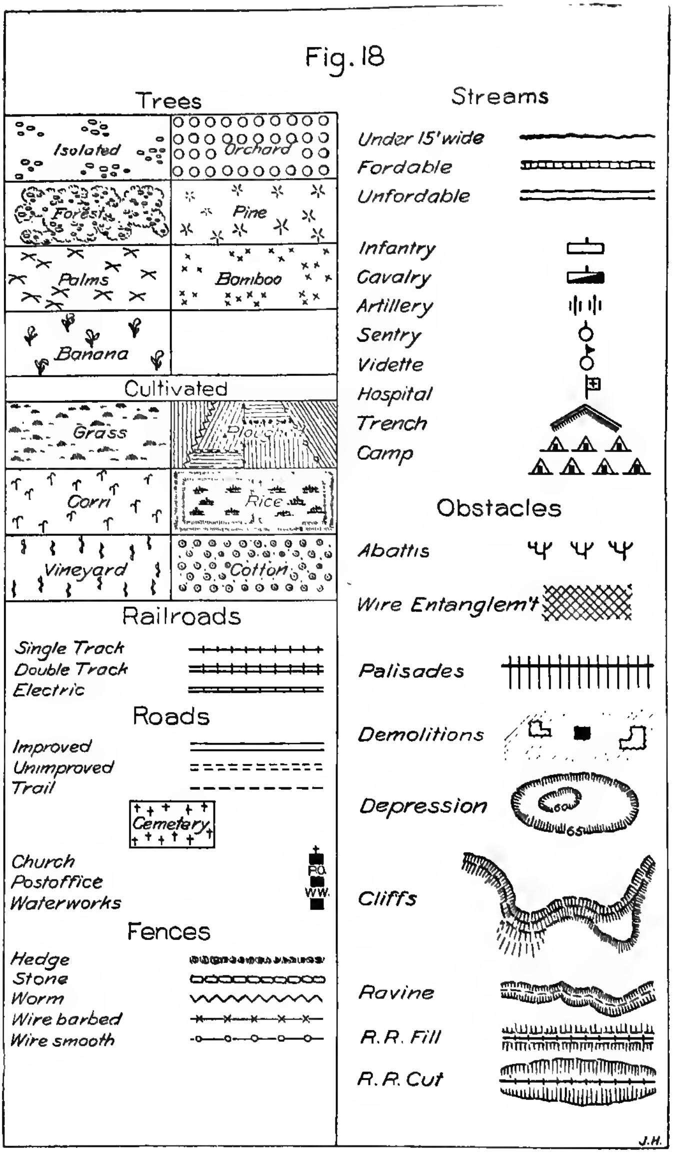


Fig. 18
Trees
Isolated
Orchard
Forest
Pine
Palms
Bamboo
Banana
Cultivated
Grass
Plough
Corn
Rice
Vineyard
Cotton
Railroads
Single Track
Double Track
Electric
Roads
Improved
Unimproved
Trail
Cemetery
Church
Postoffice
Waterworks
P.O.
W.W.
Fences
Hedge
Stone
Worm
Wire barbed
Wire smooth
Streams
Under 15' wide
Fordable
Unfordable
Infantry
Cavalry
Artillery
Sentry
Vidette
Hospital
Trench
Camp
Obstacles
Abattis
Wire Entanglem't
Palisades
Demolitions
Depression
60
65
Cliffs
Ravine
R.R. Fill
R.R. Cut
J.H.

the growth printed within the outline. Such means are especially frequent in rapid sketches, on account of the saving of time thereby secured.

By referring to the map of Fort Leavenworth furnished herewith the meaning of most of its symbols are at once evident from the names printed thereon; for example, that of a city, woods, roads, streams, etc. Where no conventional sign is used on any area, it is to be understood that growths thereon are not high enough to furnish any cover. As an exercise, pick out from the map the following details: Unimproved road, cemetery, railroad track, hedge, wire fence, orchard, streams, lake. The numbers at the various road crossings have no equivalent on the ground, but are placed on the map to facilitate descriptions of routes or positions (as in the issue of orders). Often the numbers at road crossings on maps denote the elevations of those points.

40. Figure 18 shows the conventional signs prescribed by the War Department for surveys.

The conventional signs in figure 19 are those used in German maps and are generally very similar to those used in the United States. Every officer should be familiar with them to properly use the German War Game and Tactical Problem maps.

In the following table are the English equivalents for words and abbreviations found on German maps.

WEGE—ROADS.

Saumpfad — Bridlepath (in mountains).
Fussweg—Path, Footpath.
Feld-und Waldweg—Field and forest road.
Gen. Verbindungsweg—General connecting road.
Gebesserter Weg—Improved road.
Gebauter Weg—Constructed road.
Chaussee—Highroad (macadam).
Daemme—Dams.

EISENBAHNEN—RAILROADS.

Eisenbahn—Railroad.
Strassenbahn—Street railroad.

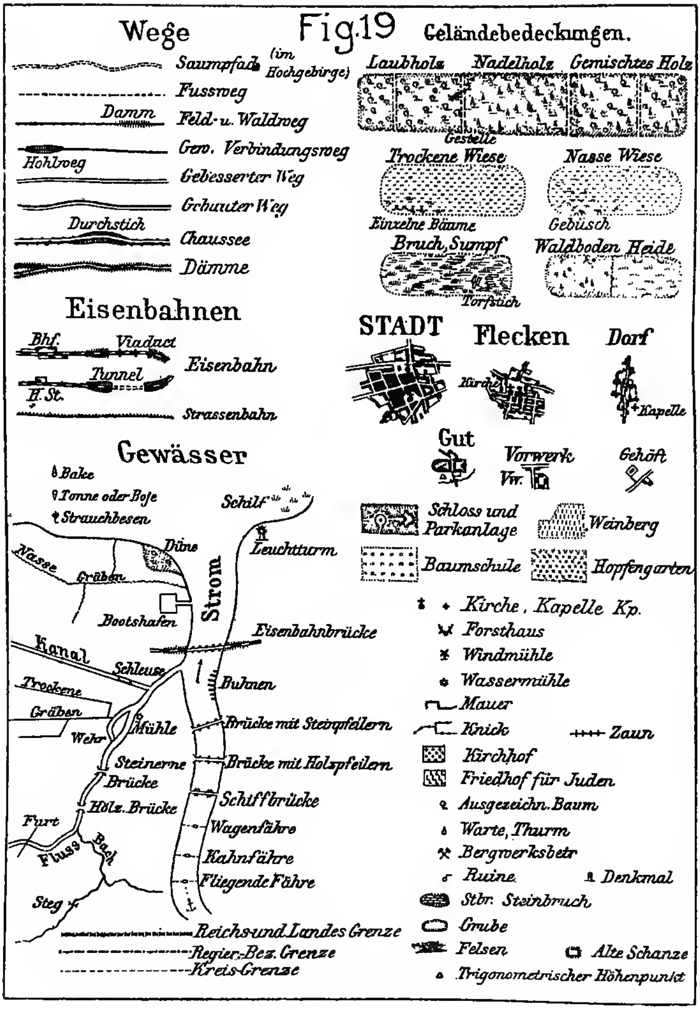
GEWAESSER—STREAMS, Water.

Schilf—Reeds.
Bake—Beacon, buoy.
Tonne oder Boje—cask or barrel used for buoy.
Strauchbesen—broom corn.
Duene—sand dune.
Nasse Graeben—wet (damp) ditch.
Strom—Stream.
Bootshafen—Boat-landing
Eisenbahnbruecke — Railroad Bridge.
Kanal—Canal.
Schleusse—Canal lock.
Trockene Graeben—Dry ditch.
Muehle—Mill.
Wehr—Weir, Dam.
Steinerne Bruecke—Stone bridge.
Hoelzerne Bruecke—Wooden bridge.
Furt—Ford.
Fluss—Stream, creek, river.
Bach—creek.
Steg—Narrow foot bridge.
Bruecke mit Steinpfeilern—Bridge with stone piers.
Bruecke mit Holzpfeilern —Bridge with wooden piers.
Shiffbruecke—Pontoon bridge
Wagenfaehre —Wagon ford, (or ferry for vehicles).
Kahnfaehre—Ferry (for foot passengers).
Fliegende Faehre—Flying ferry.
Leuchtturm—Lighthouse.
Buhne—Pier (landing stage).

GELAENDEBEDECKUNGEN—FEATURES OF THE TERRAIN.

Laubholz—trees with leaves.
Nadelholz—trees with needles.
Gemischtes Holz—trees of both kinds (mixed woods).
Trockene Wiese—Dry Meadow.
Nasse Wiese—Wet Meadow.
Einzelne Baeume—Single trees.
Bruch, Sumpf—Swamp.
Waldboden—Woods.
Heide—Prairie.

Stadt—City.
Flecken—Town.
Dorf—Village.
Gut—Manor, farm.
Vorwerk—detached farm.
Gehoeft—Farm.
Schloss und Parkanlage—Chateau and park.
Weinberg—Vineyard.
Baumschule—Nursery.
Hopfengarten—Hop Orchard.
Kirche, Kapelle, Kp.—Church, Chapel, Ch.
Forsthaus—Forester's lodge.
Windmuehle—Windmill.
Wassermuehle—Watermill.
Mauer—Wall (stone).
Knick—part wall, part fence.
Zaun—Fence.
Kirchhof—Churchyard, Cemetery.
Friedhof fuer Juden—Jewish Cemetery.
Ausgezeichn. Baum—Lone Tree.
Warte, Thurm—Town.
Bergwerksbetr—Mine.
Ruine—Ruin.
Denkmal—Memorial (statue or anything else).
Steinbruch, Stbr.—Quarry.
Grube—Pit, hole.
Felsen—Rock.
Alte Schanse—Old (abandoned) trench (rifle pit).
Trignometrischer Hoehenpunkt—Triangulation Station.
Reichs- und Landes Grenze—Kingdom and state frontier.
Regier.-Bezirk Grenze—Frontier of governmental districts.
Kreis-Grenze—District frontier.


Wege
Saumpfad (im Hochgebirge)
Fussweg
Damm
Feld- u. Waldweg
Gew. Verbindungsweg
Hohlweg
Gebesserter Weg
Gebauter Weg
Durchstich
Chaussee
Dämme
Eisenbahnen
Bhf.
Viadact
Eisenbahn
Tunnel
H. St.
Strassenbahn
Gewässer
Bake
Tonne oder Boje
Strauchbesen
Schilf
Leuchtturm
Düne
Nasse
Gräben
Strom
Bootshafen
Eisenbahnbrücke
Kanal
Schleuse
Trockene
Gräben
Buhnen
Wehr
Mühle
Brücke mit Steinpfeilern
Steinerne
Brücke
Brücke mit Holzpfeilern
Holz. Brücke
Schiffbrücke
Furt
Wagenfähre
Fluss
Bach
Kahnfähre
Fliegende Fähre
Steg
Reichs-und Landes Grenze
Regier.-Bez. Grenze
Kreis-Grenze
Geländebedeckungen.
Laubholz
Nadelholz
Gemischtes Holz
Gestelle
Trockene Wiese
Nasse Wiese
Einzelne Bäume
Gebüsch
Bruch, Sumpf
Waldboden Heide
Torfstich
STADT
Flecken
Dorf
Kirche
Kapelle
Gut
Vorwerk
Vw.
Gehöft
Schloss und Parkanlage
Weinberg
Baumschule
Hopfengarten
Kirche, Kapelle Kp.
Forsthaus
Windmühle
Wassermühle
Mauer
Knick
Zaun
Kirchhof
Friedhof für Juden
Ausgezeichn. Baum
Warte, Thurm
Bergwerksbetr
Ruine
Denkmal
Stbr. Steinbruch
Grube
Felsen
Alte Schanze
Trigonometrischer Höhenpunkt
Fig. 19

CHAPTER IV.

VISIBILITY.

41. The problem of visibility is based on the relations of contours and map distances previously discussed, and includes such matters as the determination of whether one point can or cannot be seen from another; whether a certain line of march is concealed from the enemy; whether a particular area can be seen from a given point; whether slopes are convex, concave or uniform.

On account of the inherent inaccuracy of all maps it is impossible to determine exactly how much ground is visible from any given point over a given obstructing area; that is, if a correct interpretation of the map shows a given point to be just barely visible, then it would be unsafe to say positively that on the ground this point could be seen or could not be seen. It is, however, of great importance for the student to be able to determine whether such and such a point is visible or not, within about one contour interval; or whether a given road is generally visible to a certain scout, etc. In the solution of visibility problems, it is essential to thoroughly understand the meaning of profiles and their construction, consequently these matters will be explained here.

42. *A Profile is the line cut from the surface of the earth by an imaginary vertical plane.* The

projection of this line to scale on a vertical plane is also called a profile. Figure 20 B shows a profile on the line D *a f*, figure 20 A, in which the horizontal scale is the same as that of the map, and the vertical scale is 1 inch = 40 feet. It is customary to draw a profile with a greater vertical than horizontal scale, in order that the slope of hills on the profile may appear more clearly to the eye for purposes of comparison. Always note especially the vertical scale in examining any profile; the horizontal scale is usually that of the map from which the profile is taken.

A profile is constructed as follows, Plate 8: Draw a line D′ *y*′ equal in length to D *y* on the map.* Lay off on this line from D′ distances equal to the horizontal distances of the successive contours from D toward *y* on the map. At each of these contour points drop a perpendicular down to the elevation of this particular contour, as shown by the vertical scale on the left. For example, *a* is on the contour 870 and the perpendicular is dropped down to *a*″ (870). Join successively the ends of these verticals by a smooth curve, which is the required profile of the ground on the line D *y*. ***Profile or cross section paper*** (lines ruled at right angles) simplifies the work of construction, but ordinary paper may be used.

48. Examining the profile, and drawing from

*The line D′*y*′ may be assumed to have an elevation as great as the highest point, or as low as the lowest point in the profile, so that the profile will be *entirely below* or *entirely above* this line of reference.

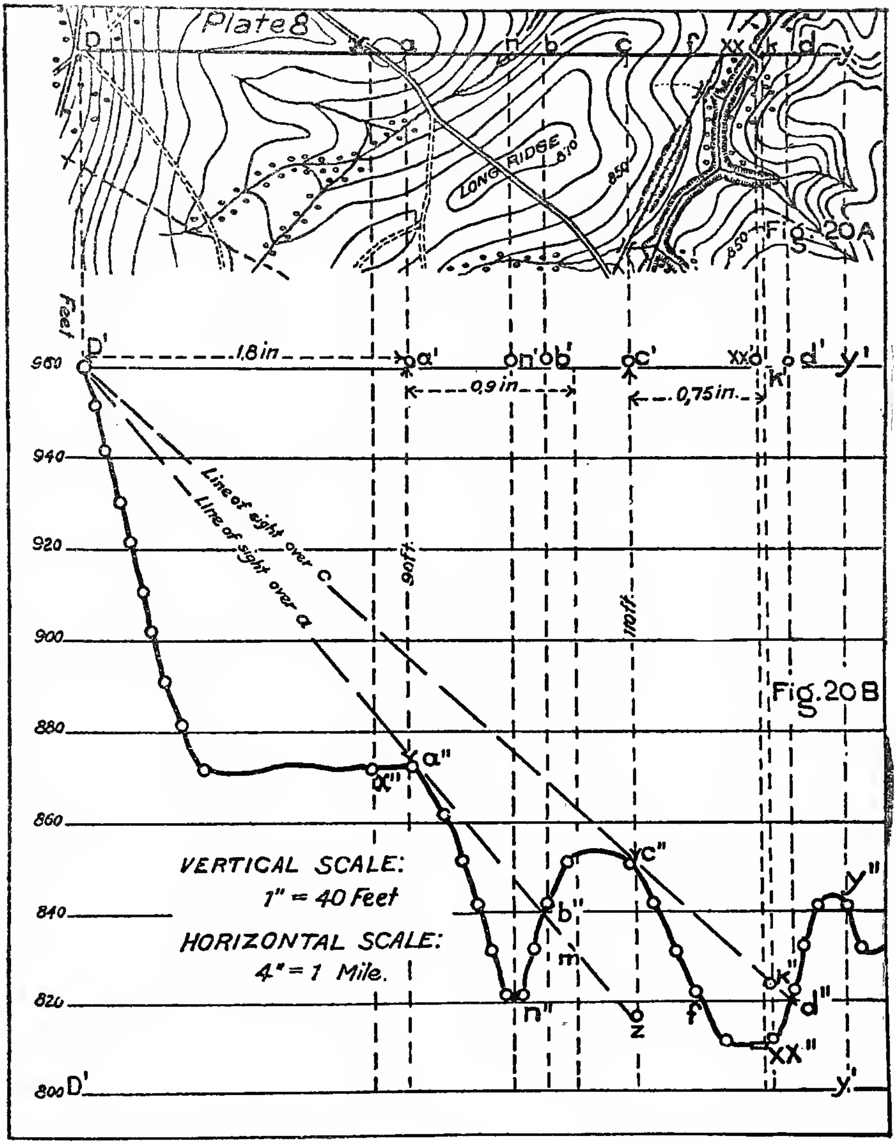


Plate 8
LONG RIDGE
Fig. 20A
Feet
1.8 in
0.9 in
0.75 in
Line of sight over c
Line of sight over a
90 ft.
Fig. 20B
VERTICAL SCALE:
1" = 40 Feet
HORIZONTAL SCALE:
4" = 1 Mile.
960
940
920
900
880
860
840
820
800

your eye at D lines tangent to the various hill tops, it is evident that looking along the line D *y*, you can see the ground as far as *a*; from *a* to *b* is hidden from view by the ridge at *a*; *b* to *c* is visible; *c* to *d* is hidden by the ridge at *c*.

1ST METHOD

By thus drawing a profile and lines of sight tangent to the various hill tops the visibility of any one point from another given point may be determined. The work may be much shortened by drawing the profile of only the observer's position (D); of the point of which the visibility is in question (Bridge XX); and of the probable obstructing points, (*a* and *c*). It is evidently unnecessary to construct the profile from D to *x*, because the concavity of the slope shows that there is no obstruction along this portion. The above method of determining visibility by means of a profile is valuable practice for learning slopes of ground, and the forms corresponding to different contour spacings.

44. Examining the profile we obtain the following important principles of visibility: (1) *Contours closely spaced on the top of a hill, gradually getting farther apart toward the bottom*, as D *x*, show a concave slope, and all points of the intervening surface are visible from top and bottom.

(2) *Contours spaced far apart at top, growing gradually closer together toward the bottom*, as *a n*, show a convex slope, and neither end of the slope is visible from the other.

(3) *Contours spaced equally distant apart*, as

c f, indicate a plane surface, and all intervening points are visible from top to bottom of the slope.

The profile is the basis of all methods of determining visibility, but their construction is too slow for general use, except in acquiring skill in map reading. A simple and rapidly applied method is as follows:

45. *2nd Method.* Examine the line D *y* on the map, and by inspection determine the point or points which will be liable to obstruct the view to the desired point, the bridge *XX*. It can be seen at once from the three principles of contour spacing that the hills at *a* or *c* will be the only points to be considered. First determine whether *a* or *c* is the obstructing point. In order that *a* may be the obstructing point, *c* must lie below the line of sight from D tangent to *a*; that is, below *z*. It will be observed that for each distance D *a* (1.8 inches) the line of sight D′ *a*″ falls 90 feet (from contour 960 to contour 870). Applying a scale of inches (or folded piece of paper) from *a* toward *f*, figure 20 A, it is seen that one-half of 1.8=.9 inches horizontally gives a drop of $\frac{1}{2} \times 90$ feet=45 feet in the line of sight, *D′ a″*, which is here at an elevation of 825, and at *c* (on the map) it is still further below *c*″ (at *z*). Hence *c* is the obstructing point with respect to the bridge *XX*. In the same way, for the bridge *XX* to be visible over *c*, it must lie *above* the line of sight tangent to *c*. Applying the scale, D′ *c*′ is found to be 3 inches long with a drop in the line of sight of 110 feet (*c*″, elevation 850). Now the point one-fourth of 3 inches=.75 inch, *forward*

from c is at k slightly beyond XX, and the line of sight in this horizontal distance has dropped $\frac{1}{4}$ of $110=27.50$ feet below c, or it is at the elevation 822.5 feet (at k''). The bridge XX is below the line of sight and therefore invisible.

46. The second method of determining visibility is a rapid approximation of that shown in the profile, and depends on the principle of similar triangles that *the drop of the line of sight at any point is proportional to the horizontal distance of that point from the apex of the triangle* (see triangles D′ c' c'' and D′ d' d'' figure 20 B). It will in general not be practicable to determine the visibility of points by this method closer than to say that the line of sight pierces the ground between two adjoining contours.

47. The explanation of this method is rather long on account of the necessity of referring constantly to the horizontal projection of the profile D y, and to the profile itself, D′ y''. The practical application, however, is rapid and simple. For example, you would solve the problem as follows: (1) Inspect the line D f and note that the only two probable obstructing points are a and c. (2) Lay the scale of equal parts on the line and find D a to be 1.8 inches and from the contours, note that the drop is 90 feet; apply $\frac{1}{2}$ of the 1.8 inches forward from a with a further drop of 45 feet and you see that the line of sight tangent to a pierces the ground before reaching c, and hence c is the obstructing point. (3) Applying the scale to

D *c*, you find it 3 inches long with a drop of 110 feet; and forward ¼ of 3 inches,=.75 inch, from *c* with a further drop of 27.50 feet, carries the line of sight beyond *XX* to *k* and about 20 feet above *XX*. Hence *XX* is invisible.

THE OBSTRUCTING POINT.

48. The point to be considered is on the side of the obstructing hill *away from the observer looking down, and toward him in looking up toward an object* whose visibility is in question. For example see *a* and *a''* Plate 8. If the profile lies directly over the top of the hill, so that it cuts the highest closed contour, the elevation of the obstructing point will be that of this highest contour as *a''* (870). If, however, the profile crosses the obstructing hill on an inclined water shed, as A *d*, figure 22, then the view may be obstructed by ground on the water shed higher than the contour. The elevation of this point *a*, is approximately found by drawing a line up the water shed and finding by interpolation the elevation of the point where this line cuts the profile line *A d*.

49. *To determine the point at which a line of sight over an intervening hill pierces the ground*: use the 2nd method to find between which two contours the line will pierce, and, having found this, construct the profile (1) of the observing point, (2) of the obstructing point, (3) of the ground between these two contours; (4) project the piercing point on to the map. For example: To find the piercing point of the line of sight from A tangent to

hill c, figure 21; find by 2nd method that it pierces between the 740 and 750 contours. Erect perpendiculars to the line Ac to locate A′ and c'; draw line of sight A′ c'. Similarly locate d' (740) and g' (750); join d' and g' by a straight line, this is the profile of the surface of the ground between d and g. The point m' at which the line of sight intersects d' g' is the piercing point and is located on the map at m by erecting the perpendicular m' m to the line Am. With cross section paper this method is very rapid, and easy, since the horizontal and

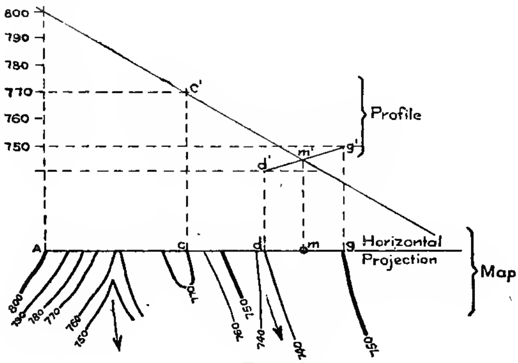


Fig. 21

SLIDE RULE FOR SOLVING VISIBILITY PROBLEMS.

50. As seen above, the solution of visibility problems requires the ability to solve proportions quickly and these proportions can be most rapidly solved with the Slide Rule. For a brief description of this valuable instrument and the methods of using it, see par. 220, Military Topography. It is well to

solve a large number of visibility problems such as are given below, first by the profile method, and then by the Scale of Equal Parts method, then with the Slide Rule, until you become thoroughly familiar with the slopes represented by different spacings of contours. You will then be able to solve almost all essential visibility questions by a careful inspection of the map.

VISIBILITY OF AREAS.

51. The ground visible from any point of observation, will in general consist of a series of areas projecting above the crests visible to the observer, in the same way that the visible portions of the line D *y* were found to be D *a, bc* etc., above the visible crests *a, c,* etc. For example, to find the portion of the area represented on figure 20 A visible to an observer with his eye at D (960): First by inspection pick out all the points of the area evidently hidden by buildings, woods, high hills, etc., and those parts certainly visible. Then by passing profiles across the area from D, similar to D *y,* find the visible and invisible parts along these profiles. Join the obstructing points along each water shed by dotted lines to show the visible crests, or horizons, beyond each of which will be areas of invisibility. Similarly join the piercing points along each slope to mark the outer limits of the areas of invisibility.

VISIBILITY PROBLEMS.

52. Problem 1. From A (890) as observing point, find: (a) the visible horizon (crests dividing the seen from the unseen areas), (b) the invisible areas, and (c) those visible in the area figure 22.

Answer: (a) the broken lines: C W; B E; N *d m a* F; Q H G; R I; K L; P *b c*. (b) C W Y; E B X; K L N *m a* F; Q H G; R I.

Solution: C W can practically be decided by inspection, but, to check this result, test the two profiles shown. The woods conceal the area between W and Y. Considering the woods south of railroad

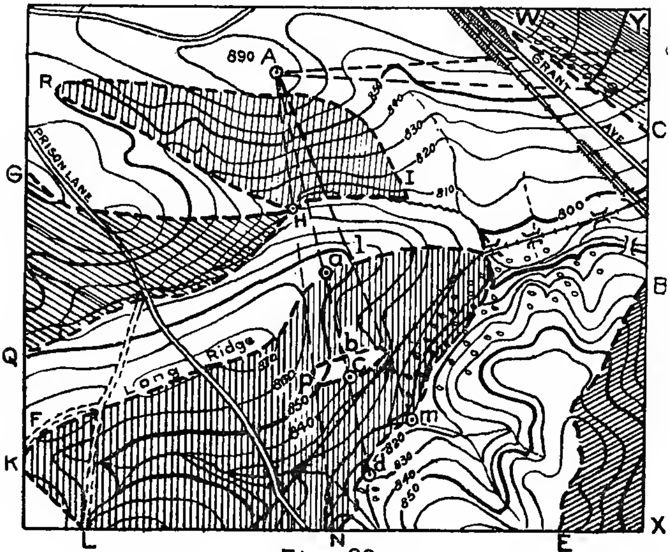


Fig. 22

as sufficiently thick to obscure the view, all of hill E would be hidden. Otherwise the crest of B E is found by inspection because of the steepness of the forward slopes toward X, as compared with the slopes of the lines of sight. The area R I is found approximately by inspection, and in the same way the visible crests along ridge F *a* and ridge H G are found. The most difficult position to solve is that south of Ridge F *a;* to determine this, draw lines tangent to the nose of each contour along the ridge as A *l m*. Find where these lines of sight pierce the ground and join these piercing points by a broken line as shown in the figure. It happens that there is a small area of visibility (*b* P *c*) on a second spur of the main ridge. This may be found by locating (method of par. 43 or par. 45) the piercing point on this auxiliary ridge, and then taking the far edge of this space as the obstructing line (*c* P) and finding over it the points of piercing, as at *d*.

With the slide rule the test on any such line as A *d* can be made in about one minute as follows:

Lay the scale of equal parts on A *d*, and leaving it there, read off values in inches below:

1st Test: At *a*, fig. 22, set 1.1 inch on Rule opposite 36 (feet drop) on the slide; read off opposite 1.53 inches (b) on Rule, 50 feet (840, piercing point) from Slide.

2nd Test: Set 1.65 inches (c) on Rule, opposite 50 feet (drop to 840 contour) on Slide. Read off opposite 2.18 inches (d) on Rule, 66 feet (824, piercing point) from Slide.

Problem 2. Is a patrol at 15 (elevation 855) visible to a scout at the letter C of the word Curran (elevation 980)? Answer, Yes. Solution: By inspection the probable obstructing point is seen to be the spur at M. Kern. Draw a line from 15 to C and take off on a piece of paper the distance from

Note: For problems 2, 3, 4, 5 and 6 see map of Fort Leavenworth.

C to the obstructing point (contour 910). This distance gives a drop in the line of sight of 70 feet (980-910). Apply this distance once more beyond the obstructing point toward 15 and it shows the line of sight just south of 15 has an elevation of 840. The patrol is above the line of sight and is therefore visible.

Problem 3. Is the patrol at 15 visible to a scout on Curran House at elevation 1020? Answer, yes.

Solution: (*2nd Method, par* 46). Draw a line from 15 to Curran House (Leavenworth Map). The probable obstructing points are determined by inspection to be Bell Point or the Spur at Dishark. Take the distance, Curran House—Bell Point (930 contour) on a piece of paper. This horizontal distance gives a drop in the line of sight 1020—930= 90 feet. Fold the paper so as to divide the above distance into 8 equal parts each equal to 11¼ feet. Apply these parts from Bell Point toward 15. The fifth division falls on the Dishark Spur where the line of sight is at elevation 873.5, consequently the Spur does not interfere. Lay off the distance already taken on the paper (Curran House—Bell Point), along the line from Curran House twice toward 15. This brings the line of sight opposite the orchard at Sharp, with an elevation of 840. The patrol is above the line of sight, hence visible.

(Note—Check these two solutions by profile method. Problem 3 is more difficult, because it is not possible to determine by inspection which is the obstructing point.)

Problem 4. How much of the road 15-E is visible from a point above McGuire House (elevation 1020)?

Method: Construct a profile of the obstructing crests and doubtful portions, see par. 49. Having constructed the profile, draw lines from the observer's position tangent to each ridge and note the hidden areas, as in figure 20 B.

(Note—Where a number of tests are to be made on one line, as in this problem, or where the exact point of piercing of a line of sight is desired, the profile method is preferable; otherwise the Slide Rule or Scale of Equal Parts methods are much more rapid).

Problem 5. Three Blue scouts are located as follows: On Schroeder's house (elevation 900); M. Kern's (elevation 920); Curran's (elevation 1050). A Red patrol is at Taylor School House (875). Can any one of the scouts see it? If so, which ones? (ignore trees).

Problem 6. Can a scout on northwest corner of the water works reservoir (870) see a battery on top of Sentinel Hill? (ignore trees).

Problems in visibility should be solved where possible on large scale maps at first.

ON USING MAPS IN THE FIELD.

53. Suppose you are in unknown country and are given a contoured map of a portion of the area your army now occupies, and are informed that later you are to make a reconnaissance based on this map. Learn the map as follows:

(1) Observe the scale, see if it is in familiar units and how many inches equal 1 mile, so that you can make rapid mental estimates of the distance between prominent points shown. For purposes of estimation the end joint of the first finger is approximately one inch long. For example, the map, plate 5, is on a scale of approximately one inch to 1 mile. You see, therefore, that Stratford is about two inches, that is about 2 miles, from Chilton. Get this scale relation firmly fixed in mind for the map under consideration.

(2) Learn the contour interval, from the numbering on the contours, or by observing the number of contour intervals between two known elevations, usually marked on hill tops or cross roads. This will give you a clear idea of the relative heights of hills and depressions of streams; and will tell you which are commanding positions, good view points, etc.

(3) Observe the position of the true and magnetic meridians, and the number of degrees declination.

(4) Pick out the streams on the ground and map and trace them by eye throughout their visible length. This is a most necessary step in acquiring a good general knowledge of the ground and map, because the streams form the framework of the area upon which the contours are based. For instance, on the map figure 15, if the streams are first traced as shown, figure 14, it will be possible to imagine the approximate location of the hill tops and ridges and a skilled sketcher would be able with

this data alone to draw a fairly good map of the area showing the ground forms.

(5) Next pick out the tops of all hills and trace the highest lines of all the ridges. You will be surprised to see how quickly the features of ground represented on the map begin to stand out clear and distinct. You will be assisted in picking out stream lines and watersheds on a properly made map, by noting that the contours heading on the stream lines are very pointed, whereas on watersheds the contours bulge out toward the bottom of hills in rounded curves. This is well shown in figure 15.

(6) Next construct (if not given) a scale of M. D's. for the map and learn the general character of slopes of the ground. See where the flattest and steepest parts occur and the approximately greatest angle of slope, also where troops can maneuver (see table of movements, par. 30).

(7) Pick out all towns and villages, noting their names, sizes, etc.

(8) Trace all roads and railroads and get a good idea which are main roads and which only field tracks.

(9) Next take up the particular points to be investigated and study the map with these in view. For instance, where are good defensive positions, camp sites, lines of observation, good roads with easy grades for the passage of trains, etc.

MAPS USED FOR WAR GAMES AND TACTICAL PROBLEMS.

54. Two of the most important uses of maps by military students are in connection with the solution of tactical map problems and war games. It is customary to solve these problems with commands at war strength, and therefore it is important to have a clear idea of the spaces on the map occupied by bodies of troops of the different arms and the distances passed over at the normal foot and mounted rates of travel. Figure 23 gives this information for maps on the scale of 12 inches to 1 mile, which are normally used for war games. For tactical problems on maps of smaller scales, take one-twelfth, one-fourth, etc., of these spaces for the same values according as the map used is 1 inch to 1 mile, 3 inches to 1 mile, etc. You should familiarize yourself with these movements and spaces before beginning the solution of problems in tactics, in order to have a clear idea of the lengths of columns and distances of travel on the map.

The Secretary Army Service Schools has for sale at small cost the following maps: Antietam, Gettysburg, Ft. Leavenworth, 12 inches to 1 mile; Benjamin Harrison, 8.08 inches to 1 mile; Pine Plains, Mt. Gretna, Leon Springs, Ft. Leavenworth, 4 inches to 1 mile; Atascadero, 3¼ inches to 1 mile; Gettysburg, American Lake, Crow Creek (Wyoming), Fort Benjamin Harrison, 3 inches to 1 mile; Ft. Leavenworth, 2 inches to 1 mile.

The maps which are most generally available for military students in our country are those of the U.

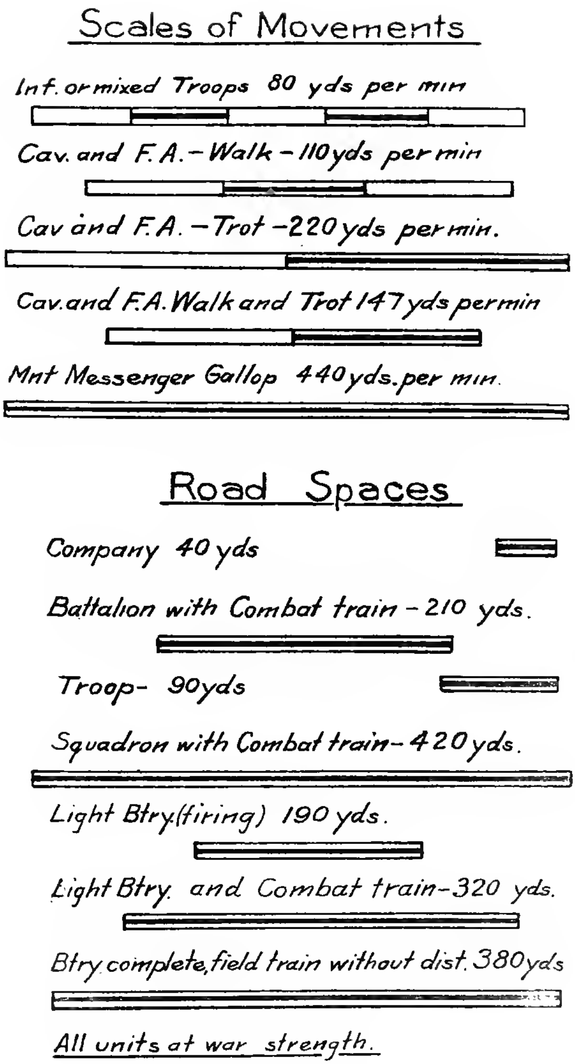

Scales of Movements
Inf. or mixed Troops 80 yds per min
Cav. and F. A. - Walk - 110 yds per min
Cav and F. A. - Trot - 220 yds per min.
Cav. and F. A. Walk and Trot 147 yds per min
Mnt Messenger Gallop 440 yds. per min.
Road Spaces
Company 40 yds
Battalion with Combat train - 210 yds.
Troop - 90 yds
Squadron with Combat train - 420 yds.
Light Btry. (firing) 190 yds.
Light Btry. and Combat train - 320 yds.
Btry. complete, field train without dist. 380 yds
All units at war strength.

Fig. 23

S. Geological Survey. These maps are made on three scales, as follows: (1) R. F. 1÷62500, or about 1″=1 mile, of the more thickly settled portions of the country; (2) R. F. 1÷125000, or about 1″=2 miles, of the moderately settled areas; (3) R. F. 1÷250000, or about 1″=4 miles, of the desert areas. The contour interval varies according to the relief of the ground. On each sheet are placed graphical scales of inches to miles, and centimeters to kilometers; the contour interval; a true meridian; a magnetic meridian; the mean declination at the date the map was made; and the latitude and longitude of the boundaries of the sheet. Each is named from the principal town covered by the sheets. On these maps water features are shown in *blue,* contours in *brown,* works of man and lettering in *black.* Although these maps lack certain details of importance to military students, yet they are of great value in solving military problems.

The Director, U. S. Geological Survey, Washington, D. C., will furnish, on request, a set of indexes of maps of the United States issued by his department. A single map costs five cents. Every officer ought to have the map of the section where his company is stationed, as well as the maps wherein are located the maneuver camps that his organization visits, and the four sheets around Gettysburg of which the 12 inch and 3 inch maps are for sale at the Service Schools.